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PATENT SPECIFICATION

DRAWINGS ATTACHED

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International Classification: —H 02 k 9/197

COMPLETE SPECIFICATION

Improvements in or relating to Electrical Machines

We, SOCIETE GENERALE DE CONSTRUCTIONS ELECTRIQUES ET MECANIQUES (ALSTHOM), of 38 Avenue Kleber, Paris (16°), France—a French Body Corporate, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement: —

The present invention relates to electrical machines, and has for an object improvements therein.

During the asynchronous starting of a synchronous or asynchronous electric motor there is developed in the damper winding energy in the form of heat which depends upon the inertia of the machine to be started and upon the opposing torque of apparatus coupled thereto.

That part of the temperature rise which is due to the opposing torque can usually be reduced to a low value by momentarily modifying the opposing torque. In the case of a turbo-alternator set in which the alternator is used as a motor and the turbine as a pump, it is possible for instance to reduce the opposing torque by releasing the drive between the turbine and the alternator, by providing a bypass link for the fluid to be pumped, or by clearing the turbine wheel of water.

On the other hand, the temperature rise due to the inertia of the set cannot be reduced and, in the case of high-inertia sets such as those used in hydraulic pumping power stations, this temperature rise can reach unacceptable levels that preclude asynchronous starting.

It is known to cool the winding of an electrical machine by continuous circulation of liquid. When such a winding is located on a rotating part, a cooling method of this kind calls for a system of complex design for the admission and extraction of the liquid.

It is a specific object of the invention to provide a simple and efficient means for cooling the damper windings of electrical machines when the latter are to be started as motors.

The invention consists in an electric machine having a rotor provided with a damper winding in thermal contact with cooling ducts, wherein a cooling-liquid reservoir is located in the central part of the rotor and passages interconnect said reservoir and the ends of said cooling ducts in such manner as to cause a natural circulation of the cooling liquid to be established between said ducts and said reservoir when the electric machine is started as a motor.

In the case of a vertical rotor, this natural circulation can be accomplished by a thermo-siphon effect by using the temperature rise sustained by the damper winding. In this case, certain of said passages interconnect the upper ends of said cooling ducts with the upper part of said reservoir, and the other passages connect the lower end of the cooling ducts with the lower part of the reservoir.

Alternatively, natural circulation of the cooling liquid can be obtained through the dynamic effects engendered during rotation or starting of the rotor, such as through the momentum resulting from the difference between the tangential velocities of the cooling liquid reservoir and of the liquid itself. Said interconnecting passages accordingly open out into said reservoir and are circumferentially inclined therein, to one side in the case of those connected to one particular end of said cooling ducts, and to the other in the case of those connected to the other end of said ducts.

In order to make use of the inertia force of the cooling liquid during acceleration of the rotor for the purpose of achieving a natural circulation of such liquid, said reservoir may furthermore be partitioned by radial walls and said interconnection pas-

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sages caused to terminate thereat after having each passed through one of these walls whereby those of the interconnecting passages which are connected to one end of said cooling ducts open out on one side of said walls and those which are connected to the other end of said cooling ducts open out on the other side of said walls.

The rotor shaft of the electrical machine may be hollow and a portion of its interior may form said reservoir.

In order that the invention may be more clearly understood, reference will now be made to the accompanying drawings which show certain embodiments thereof by way of example, and in which:—

Figure 1 shows in partial section a portion of a vertical rotor utilizing cooling liquid circulation in the damper winding on the thermo-siphon principle,

Figures 2 and 3 show in partial section, respectively in side elevation and in plan view on the line III—III of Figure 2, a portion of a rotor utilizing cooling liquid circulation in the damper winding responsive to the relative tangential velocities of the cooling liquid contained in the liquid reservoir and of the reservoir itself, and

Figure 4 is a plan view in partial section of a portion of a rotor utilizing cooling liquid circulation in the damper winding responsive to the inertia force of the cooling liquid during speeding up of the rotor.

Referring now to the drawings, in the embodiment illustrated in Figure 1 a vertical hollow shaft 1 carries a rotor 2 fitted with damper winding bars 3. A portion of the interior of the hollow shaft 1, defined by the walls 4 and 5, forms a cooling liquid reservoir 6. Within the bars 3 are formed ducts 7 capable of being used directly as cooling ducts, but into which tubes 8 have been inserted in this case. The bottom ends of tubes 8 pass into a manifold 9 and their upper ends into a manifold 10. Manifold 9 communicates with the lower part of reservoir 6 through passages 11 and manifold 10 communicates with the upper part of reservoir 6 through passages 12.

When the rotor is rotating and no heating occurs in the bars 3, the system will produce no liquid circulation since the pressures set up in passages 11 and 12 by the centrifugal force cancel each other out. If the bars 3 should heat up, as happens when starting as a motor, convection will cause the hot liquid to rise through the tubes 8 towards manifold 10 and the difference in the densities of the liquid in the passages 12 and the liquid in the passages 11 will produce an active circulation of liquid between the tubes 8 of bars 3 and the reservoir 6. Reverse flow would take place in the case of a liquid that undergoes a temperature-dependent variation in density the reverse of that of water.

If the heat transfer into the bars 3 is large and quick enough locally to raise the liquid to boiling point in the tubes 8, the vapour given off into the passages 12 will fill the latter with a mixture of liquid and vapour, of density very markedly lower than that of the liquid contained in the passages 11, thereby considerably increasing the difference in pressure between the passages 11 and 12 and increasing the circulation. The vapour formed thus locally condenses inside reservoir 6, giving up its heat to the liquid contained therein and increasing its mean temperature.

The machine can be constructed so that the increase in temperature of the liquid in reservoir 6 does not raise the liquid to boiling point at normal pressure, and to that end recourse must be had to a large sealed reservoir with walls constructed to withstand low pressure. Alternatively, the machine could be constructed with a smaller liquid reservoir, which would result in the boiling temperature being exceeded at normal pressure, in which case it will be necessary to use reservoir walls constructed to withstand a higher pressure. Lastly, it would be possible to use a much smaller liquid reservoir if boiling of the liquid contained in the reservoir and escaping of the vapour into the atmosphere is not a disadvantage, but in that event the reservoir will have to be re-filled periodically.

The heat-resisting capacity of such a damper winding is thus considerably augmented and enables high-inertia sets to be started asynchronously without undue heating up.

Referring now to Figures 2 and 3, the hollow shaft 1 widens out into a cylinder 13 which forms the reservoir containing the cooling liquid 14. As in the case of the embodiment of Figure 1, the tubes 8 forming the damper winding cooling ducts open out into manifolds 9 and 10 connected to the reservoir through passages 11 and 12. Figure 3 clearly shows the oppositely-directed ends 15 of passages 12 associated with manifold 10 with respect to the ends 16 of the passages associated with manifold 9. When the rotor rotates, the internal surface of cylinder 13 entrains the cooling liquid with it as the result of friction. But since the coefficient of viscosity of the liquid is comparatively low, its angular velocity is much lower than that of cylinder 13. The momentum resulting from the angular velocity differential between the cooling liquid and the cylinder 13 thus creates a pressure in passage 11 and a depression (partial vacuum) in passage 12, thereby stimulating circulation of the cooling liquid through the tubes 8.

Figure 4, in which parts similar to those of Figure 3 are designated by like reference numerals, shows a cylinder 13 partitioned by radial walls 17, with the ends 15 and 16 opening out respectively on opposite sides of

these walls. As the rotor is speeded up, the cooling liquid responds to its own inertia force and is constrained to flow through the damper winding, as in the case of Figure 3. The partition walls 17 may extend over the entire height of reservoir 14, or else be provided only facing the ends 15 and 16.

As shown in Figure 2, the liquid circulates through the tubes 8, under the dynamic effects of speeding up of the rotor, in the same direction as that which the heating up of the dampers tends to produce, but could alternatively be caused to circulate in the opposite direction.

WHAT WE CLAIM IS:—

1. An electrical machine having a rotor provided with a damper winding in thermal contact with cooling ducts, wherein a cooling liquid reservoir is located in the central part of the rotor and passages interconnect said reservoir and the ends of said cooling ducts in such manner as to cause a natural circulation of the cooling liquid to be established between said ducts and said reservoir when the electrical machine is started up as a motor.

2. A machine as claimed in claim 1, wherein, when said rotor is of the vertical kind, some of said passages interconnect the upper end of said cooling ducts with the upper part of said reservoir and the other passages interconnect the lower end of said cooling ducts with the lower part of said reservoir.

3. A machine as claimed in claim 1, wherein said passages open out into said reservoir and are inclined circumferentially, to one side in the case of those connecting with one particular end of said cooling ducts, and to the other side in the case of those connected to the other end thereof.

4. A machine as claimed in claim 2, wherein said reservoir is partitioned by radial walls and said passages terminate at said walls after each has passed through one thereof, whereby those of said passages which connect with one particular end of said cooling ducts open out on one side of said walls and those which connect with the other end of said cooling ducts open out on the other side of said walls.

5. A machine as claimed in claim 1, wherein its shaft is hollow and a portion of the interior thereof forms said reservoir.

6. An electrical machine rotor, substantially as hereinbefore described with reference to Figure 1 of the accompanying drawings.

7. An electrical machine rotor, substantially as hereinbefore described with reference to Figures 2 and 3 of the accompanying drawings.

8. An electrical machine rotor, substantially as hereinbefore described with reference to Figure 4 of the accompanying drawings.

9. An electrical machine incorporating a rotor as claimed in any one of claims 6, 7 and 8.

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3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

fig.1

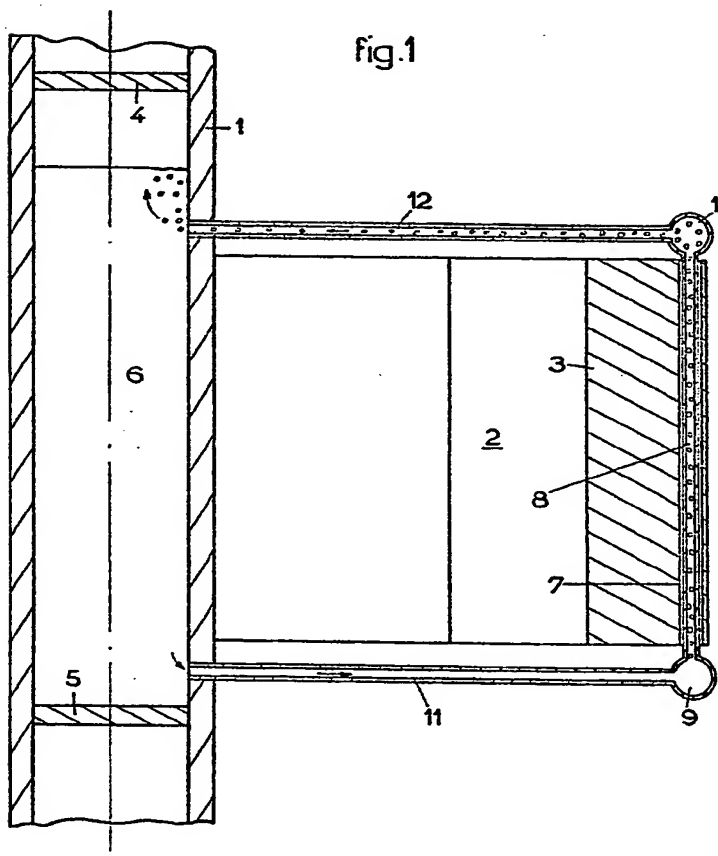

Fig.2

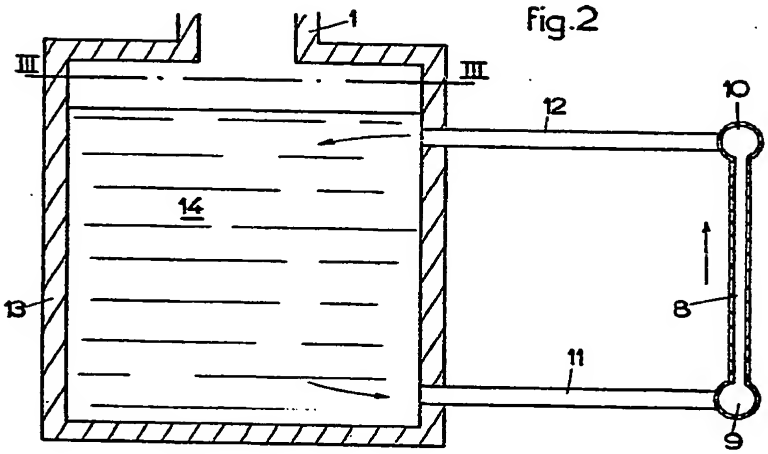

Fig.3

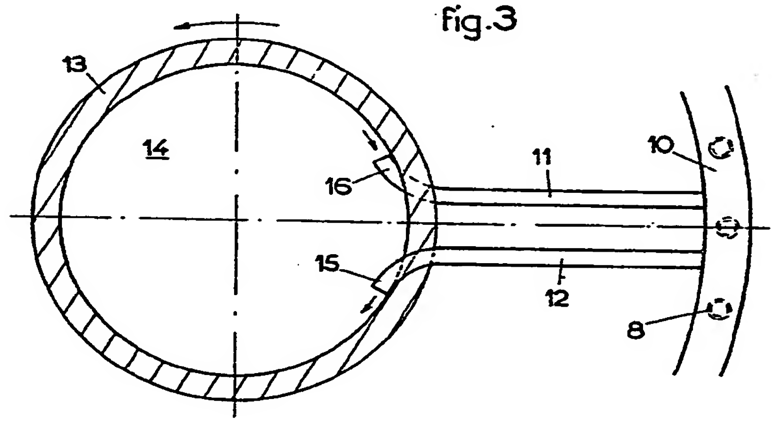

Fig. 4